JENSEN HUGHES

March 4, 2024

Mr. Brent Hardy
Shumsky & Backman
PO Box 56028
Portland, OR 97238-602
via email: Brent@Shumsky-Backman.com

Re: Homesite Insurance Company v. Norcold, Inc., et al.
Loss Location: 12312 127th Ave NE, Lake Stevens, WA 98258
Date of Loss: January 29, 2021
JH File No.: 1A0461291

# EXPERT DISCLOSURE REPORT

Dear Mr. Hardy,

The Shumsky & Backman firm retained Jensen Hughes to determine the origin and cause of a structural fire involving a residential hanger/garage that occurred on January 29, 2021, at the residence located at 12312 127th Ave NE, Lake Stevens, WA 98258. The fire investigation identified a 2006 Monaco Diplomat 40PAQ motorcoach located in the structure at the time of the fire.

Pursuant to your request, Jensen Hughes has prepared the attached expert disclosure report. If you have any questions concerning this report, please contact me at (465) 775-5550.

Respectfully submitted by:

Jeffrey Marsh
Senior Electrical Engineer, Forensics
Jensen Hughes

Jonathan Contreras, PE
Senior Metallurgical & Materials Engineer
Jensen Hughes

Scott Roberts, CFI
Senior Fire Investigator
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# ENCOMPASS INSURANCE COMPANY
# V.
# NORCOLD, INC.

## UNITED STATES DISTRICT COURT
## DISTRICT OF WASHINGTON

## CASE NO. 2:23-CV-00231-JCC

## MARCH 4, 2024

## JENSEN HUGHES FILE NO. 1A0461291
## DATE OF LOSS: JANUARY 29, 2021

***REPORT PREPARED BY:***

**Jeffrey Marsh**
**Senior Electrical Engineer**
**Jensen Hughes**

**Jonathan C. Contreras**
**Senior Metallurgical + Materials Engineer**
**Jensen Hughes**

**Scott Roberts, CFI**
**Senior Fire Investigator**
**Jensen Hughes**

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# 1.0 BACKGROUND

The subject motorhome was a 2006 Monaco motorcoach, Diplomat 40PAQ model. The VIN for the motorhome was 1RF43464162037977.

The subject fire occurred whilst the motorhome was parked for the winter in the detached structure that encompassed a hanger and garage. The 39' x 90' garage was constructed in 2019 on the south wall of the existing hanger. The hanger/garage housed a number of recreational and collectible vehicles including eight (8) cars, seven (7) motorcycles, while the garage housed two (2) boats, one (1) golf cart, one (1) airplane, four (4) trailers and one (1) 40' motorcoach. The motorcoach was parked in the east stall of the garage, along the adjoining wall between the hanger and the garage.

On the evening of January 28, 2021, the motorcoach was connected to shore power from a wall outlet located on the southeast side of the garage. LP gas for the motorhome had been turned off prior to the fire. Inside the motorcoach, a stand-alone dehumidifier and a stand-alone oil filled radiant electric heater were operating and both were plugged directly into wall receptacles of the motorcoach. Mr. Phillips went into the motorcoach around 7:00 PM to drain water from the dehumidifier unit which was performed every 2-3 days. Upon his entrance into the motorcoach, he heard the motorcoach refrigerator beeping and observed the refrigerator's control panel flashing, indicating an error. He opened the refrigerator door and observed the interior light did not energize. On the refrigerator, he pressed the OFF button followed by the ON button, and the refrigerator started up again. The refrigerator stopped beeping and appeared to be operating normally. The refrigerator mode was originally set to "Auto" and he changed the mode to "AC" and then left the RV.

At approximately 2:59 AM on January 29,2021, a neighbor witnessed fire inside the subject hanger/garage and called 911. At approximately the same time, Mr. and Mrs. Phillips were awakened by their dogs making noise. They observed a bright light at the hanger/garage through their bedroom window and called 911. Mr. and Mrs. Phillips went outside and observed flame penetration through the roof of the new garage addition where the motorcoach was parked. They both moved towards the west side of the new addition and reported they observed that the bulk of the fire was where the motorcoach was parked.

Snohomish County Fire Department (FD) arrived on scene at 3:11 AM and observed hot fire gases and flames venting from the west (garage) side of the structure and initiated a defensive fire attack. The FD departed the scene at 11:55 AM. The FD fire investigation reported the motorhome was the origin of the fire and three possible ignition sources being the operating dehumidifier, portable electric oil filled radiant electric heater, or the failure of the refrigerator/freezer located in the motorhome.

An initial site inspection was conducted on January 30, 2021, by JH Lead Fire Investigator, Scott Roberts. A follow-up site examination was conducted on February 2, 2021, by JH Lead Fire Investigator - Scott Roberts, JH Senior Electrical Engineer, Jeff Marsh, and Snohomish County Fire Marshal's Office, Deputy Fire Marshal, Daniel Lorentzen. The site examination noted fire patterns consistent with the origin in the garage on the west wall of the hanger and was supported by first witness observations. Investigation of the motorcoach, parked at this location, revealed the dehumidifier, oil radiant electric heater, and the motorcoach refrigerator.

The dehumidifier was purchased in 2008 from Fry's Electronics, manufactured by GE, model: APEL 70TT. Mr. Phillips reported no issues in the operation of the dehumidifier. No information was available on the oil radiant electric heater and no reported issues in its operation.

The examination of the Norcold refrigerator revealed that the refrigerator had a perforation in the boiler tube caused by internal corrosion of the refrigerator's cooling unit boiler tube. The perforation allowed combustible liquids and flammable gases and vapors to be expelled under high pressures into the rear of the refrigerator. The flammable gases/vapors expelled from the perforation of the boiler tube and were ignited by competent ignition sources in and around the refrigerator. This type of a failure has been known to cause fires in Norcold-branded gas absorption refrigerators and hence have been recalled for fire causation. The fire most likely spread from the boiler tube at the

back of the refrigerator, to the combustible materials inside the refrigerator compartment, and upwards to the motorhome ceiling.

A thermocouple control device to monitor the boiler temperatures was added to the refrigerator as part of the HTS recall. This device was present at the time of the fire and remained installed on the refrigerator during its recovery from the scene. A junction box and circuit board collected with the evidence were dimensionally similar to the components installed as part of the HTS, but the extent of damage to these components prohibited their identification with any absolute certainty. Note that these items were recovered in the fire debris directly beneath the motorcoach frame where the refrigerator was installed.

Jensen Hughes has examined many other absorption refrigerators that have caused fires, and several of them were manufactured by Norcold. The boiler tube on those refrigerators were found to have been heavily corroded prior to the fire and led to a premature leak of the contents of the refrigeration system into the area behind the refrigerators, similar to the subject refrigerator of this investigation. The leak allowed flammable gases to be expelled and ignited. Based on its location, the perforation of the boiler tube was consistent with the refrigerator being the cause of the fire.

Norcold, Inc., refrigerators have been subjected to numerous recalls for this very condition. Norcold states in their recall documentation that escaping refrigerant fluid can result in a fire. Norcold has conducted five recall campaigns on this model of refrigerator [in 2002, 2008, 2009 (twice), and 2010]. All five recalls involved leaks of the refrigerator boiler tubing and the risk of fire caused by the leaks. The first recall in 2002 involved a small population of 1200 Series refrigerators and offered as a remedy a new cooling unit with a different weld design. It appears that the subject refrigerator was part of this recall population and the HTS recall modification was installed. The 2010 recall was extended to the entire population of 1200 Series refrigerators manufactured since 1996, and employed a new remedy, a High Temperature Sensor (HTS), attached directly to the refrigerator boiler tube. The purpose of the HTS was the same as the TSS: to sense temperature at the boiler tube and cut off power to the electric heaters when a setpoint was reached. All five recalls cautioned that if a leak occurred and the unit continued to operate, hydrogen and ammonia gases may be expelled and could be ignited, resulting in a fire.

The 2009 recall utilized a simple, thermal, bi-metallic limit switch to detect high temperatures. This recall was short lived, as Norcold soon realized that the response time of the switch was insufficient at disabling power in sufficient time to prevent a fire. During the 2010 recall, the HTS thermocouple (with a much faster response time) was used to detect high temperatures that could result in a fire. However, even with the HTS thermocouple attached, Jensen Hughes has investigated fires caused by Norcold refrigerators.

While Norcold has initiated five product safety recalls of their 1200 Series refrigerators due to the fire risk caused by leaking refrigerator cooling unit boiler tubes, none of the recalls or recall remedies addressed the root cause of boiler tube failure, corrosion of the boiler tube wall. Norcold determined that the cause of these leaks was internal corrosion of the boiler tube. Norcold’s internal records, and Jensen Hughes’ own investigations of other Norcold refrigerators, confirmed that fires caused by leaking refrigerator boiler tubes continued in refrigerators both with and without the recall devices. This is because these devices do not cure the underlying corrosion problem that results in a leak of highly flammable gases, which are inevitably ignited, resulting in a fire.

## 2.0 SCOPE OF WORK

To date, Jensen Hughes has completed the following tasks:

- **2.1** Conducted an initial scene inspection on January 30, 2021.
- **2.2** Conducted a second scene examination and collected evidence on February 2, 2021.
- **2.3** Conducted a joint laboratory examination on June 29, 2021.

**2.4** Conducted a joint laboratory examination on July 28, 2021.

**2.5** Reviewed file materials, including but not limited to the following:

1. 2006 Diplomat product information brochure
2. GE dehumidifier product information
3. Image of Norcold controls
4. Complaint for Damages and Notice of Removal to Federal Court
5. 2023.05.05 Norcold's Objections and Answers to Plaintiff's 1st Rogs
6. 2023.05.05 Norcold's Objections and Responses to Plaintiff's 1st RFPs
7. 2023-07-21 D's Supplemental Objections and Responses to P's RFP
8. Norcold Confidential Production Documents, NOR_000828 – NOR_001130; NOR_001133 – NOR_001888 (including but not limited to: system assembly information, schematics, drawings, specifications, parts lists, instructions, warning labels, procedures, work instructions)
9. Norcold Production Documents, NOR_000001 – NOR 000827 (including but not limited to: ANSI Z21.19 2002, Certificate of Compliance, Management System Certificate, Installation Manual for 121X Series, Owner's Manual for 121X Series, Warranty Statement, Service Manual for 121X Series, Parts List 1210 Series, Test Information for 12537033, Snohomish County Fire Marshal Incident Report and Photographs, ); NOR_01131 – NOR_001132 (Consumer Use Tips Guide)
10. Jamie L. Petty-Galis Expert Report, dated October 30, 2023, titled "File No. GTE012 – Metallurgical Evaluation of Norcold Refrigerator Cooling Unit from 1999 Holiday Rambler Endeavor RV"

**2.6** Reviewed the following NHTSA Recall documents, including but not limited to the following:

1. Thor Motor Coach Dealers and Service Centers Safety Notification, January 12, 2011
2. ARP versus Norcold Recall, undated, https://www.arprv.com/arp-versus-norcold-recall.php
3. Norcold 1200 Series Recall – NHTSA 10E-049 – Norcold Fix – Norcold Control, undated, https://www.arprv.com/arp-versus-norcold-recall.php
4. Norcold Service Manual, Publication No. 630613B, August 10, 2007
5. Troubleshoot Norcold Recall – Reset Recall – Fridge Off – Norcold 634737, undated, https://www.arprv.com/arp-versus-norcold-recall.php
6. Tilt monitor and stress controller for absorption type refrigerator, US Patent, US 9.228,773 B2, 2016
7. Norcold Recall Notice, NHTSA 08E-030, March 25, 2008
8. Norcold Recall Notice, NHTSA 09E-026, May 5, 2009
9. Norcold Recall Notice, NHTSA 09E-027, May 5, 2009
10. Norcold Recall Notice, NHTSA 10E-49, October 7, 2010
11. Norcold Recall Notice, NHTSA 10E-49, Revised October 23, 2010
12. Norcold Safety Recall Notice, NHTSA 10E-049, November 2, 2010

13. NHTSA Letter, NHTSA 10E-049, November 2, 2010
14. Norcold Equipment Safety Recall Quarterly Reports, 2008 – 2011

**2.7** Reviewed the following reference materials:

1. National Fire Protection Association, *NFPA 921: Guide for Fire and Explosion Investigations,* 2017 and 2021 Editions
2. Society of Fire Protection Engineers, *The SFPE Handbook of Fire Protection Engineering*, 2nd Edition
3. DeHaan, J., *Kirks Fire Investigation*, 6th Edition
4. National Fire Protection Association, *Fire Protection Handbook*, 19th and 20th Editions
5. National Fire Protection Association, *NFPA 54 National Fuel Gas Code*
6. Babrauskas, V., *The Ignition Handbook*, 2003
7. Gummer, J. and Hawksworth, S., "Spontaneous Ignition of Hydrogen, Literature Review," prepared by the Health and Safety Laboratory for the Health and Safety Executive, 2008.
8. Althouse, A., Turnquist, A., and Bracciano, C., *Modern Refrigeration and Air Conditioning*, 1996.
9. Xu, B. et al, "Numerical study on the spontaneous ignition of pressurized hydrogen release through a tube into air," *Journal of Loss Prevention in the Process Industries*, vol. 21, issue 2, March 2008, pp. 205-213.

**2.8** Prepared this Expert Disclosure Report.

## 3.0 FIRE SCENE INVESTIGATION

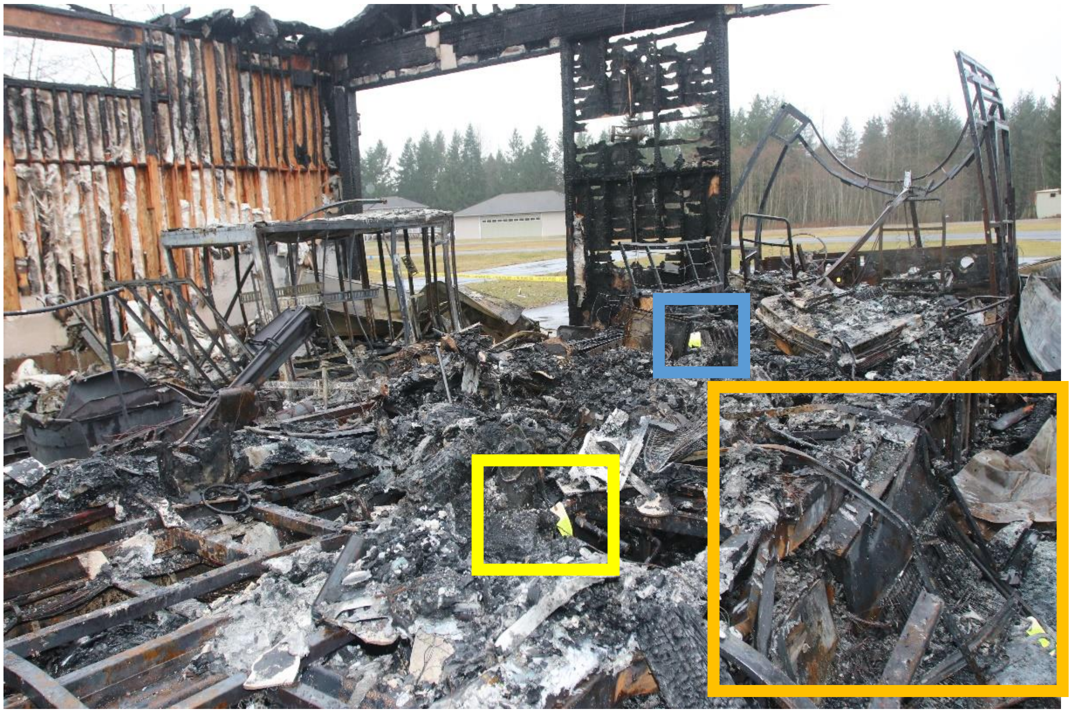
The fire scene was investigated by Scott Roberts, CFI and Jeff Marsh, Senior Electrical Engineer. Mr. Roberts was on scene on multiple occasions; January 30, 2021 and February 2, 2021. Mr. Roberts conducted his examination in the presence of the Snohomish County Fire Marshal Dan Lorentzen. He examined the burn patterns, interviewed the witnesses, and analyzed the fire dynamics according to NFPA 921, *Guide for Fire and Explosion Investigations 2021.*

The witness placed the fire at or within the location of the of the 2006 Monaco motorcoach. The RV was plugged into shore power. The RV shore power cord was plugged into a 240-volt wall mounted receptacle located in the southeast end of the garage.

The hanger and the attached garage suffered extensive fire damage during the fire event. The entire roof structure over both sections were consumed during the fire and the interior and exterior wood wall studs received extensive fire damage. Examination of the fire patterns, leading from the exterior of both structures inward revealed the origin of the fire to be at the passenger side mid-section of the motorcoach. The directional location would be on the north side of the motorcoach. The patterns observed included wood char patterns and oxidation patterns. The fire scene examination further disclosed that within the area of origin within close proximity to each other, were the dehumidifier, oil radiant heater and the motorcoach refrigerator, which were all collected for further forensic evaluation. At the time of the site examination, we could not rule out any of the three items due to the extensive fire damage.

**Photograph 1. 01-30-2021 SLR, IMG_0003: West exposure of the structure. Arrow indicating the general area of origin. Blue box indicates the motorcoach location.**

**Photograph 2. 01-30-2021 SLR, IMG_0132: North (passenger) side of the motorhome and area of origin.**



**Photograph 3. 01-30-2021 SLR, IMG_0133: Area of origin with appliances identified. Yellow: dehumidifier, blue: portable heater and orange: refrigerator.**

**Photograph 4. 01-30-2021 SLR, IMG_0216: North interior wall of the garage adjacent to the motorhome. Origin area is detailed in the red box. The yellow arrows indicate the motorcoach location. Fire damage to the wood wall studs more pronounced in the area adjacent to the location of the refrigerator.**

Mr. Phillips described having issues with the refrigerator on the evening before the fire. He stated he went into the motorhome around 7:00 PM to drain water from the dehumidifier unit which was performed every 2-3 days. Upon his entrance into the motorcoach, he heard the motorcoach refrigerator beeping and observed the refrigerator's control panel flashing, indicating an error. He opened the refrigerator door and observed the interior light did not energize. On the refrigerator, he pressed the OFF button followed by the ON button, and the refrigerator started up again. The refrigerator stopped beeping and appeared to be operating normally. The refrigerator mode was originally set to "Auto" and he changed the mode to "AC" and then left the RV.

NFPA 921 asks investigators to consider "fire dynamics" when considering the origin of the fire. In this matter, we have considered alternate hypotheses for the origin of the fire. Based on the witness accounts and fire patterns, the fire likely originated within the RV. From a fire aspect, the RV provides a large fuel source and would explain why the fire spread from the center of the building outward. We also know that the RV had three operating heat sources capable of igniting the fire. We considered the multiple hypotheses that the fire originated from the refrigerator, the dehumidifier or the radiant heater. Collectively, Jensen Hughes has investigated many fires that have started within absorption refrigerators produced by Norcold and others, and we know absorption refrigerators have the ability to start and spread fires within recreational vehicles, which was why they were recalled.

The first fuel for the fire was likely the escaping flammable gases from the refrigerant within the boiler section of the absorption refrigerator. The gases are gaseous ammonia and hydrogen, both of which are flammable. Secondary fuel sources were the wood framing of the refrigerator cabinetry surrounding the refrigerator. The fire likely spread from the back of the refrigerator once the escapes gases ignited, up and into the wooden cabinetry and into the ceiling of the motorcoach.

## 4.0 EVIDENCE EXAMINATIONS

A destructive evidence examination was performed on June 29, 2021, with representatives for the Compass Insurance Company and Norcold. A second destructive evidence examination was performed on July 29, 2021, with representatives for Compass Insurance Company, Norcold, and Essentia. During these examinations, the evidence collected from the scene was disassembled and inspected to determine if any of the devices caused the fire.

### 4.1 The Oil-Filled Radiant Heater.

**4.1.1** Visually examined and photographically documented the remnants of the oil radiant electric heater (Item #2) in its as-received condition, as seen in Figures 1 and 2.

**4.1.2** Disassembled the heater's control panel, exposing components and electrical connections, shown in Figures 3.

**4.1.3** Visually examined and photographically documented the heater's thermostat switch, level switch and heater element, as seen in Figures 4 and 5.


**Figure 1. Item #2, oil filled electric radiant heater.**


**Figure 2. Item #2, control panel of oil filled electric radiant heater.**


**Figure 3. Item #2, control panel removed.**


**Figure 4. Item #2, thermostat.**

**Figure 5. Item #2, heater element connections.**

### 4.2 The Dehumidifier

**4.2.1** Visually examined and photographically documented the remnants of the dehumidifier (Item #3) in its as-received condition, as seen in Figure 6.

**4.2.2** Disassembled the dehumidifier to visually examine and photographically document internal electrical components and wiring of the dehumidifier (Item #3), shown in Figures 6 and 7.

**4.2.3** X-rayed the dehumidifier (Item #3) and circuit boards.

**4.2.4** Visually examined and photographically documented the heater's thermostat switch, level switch and heater element, as seen in Figure 6.


**Figure 6. Item #3, dehumidifier.**


**Figure 7. Item #3, dehumidifier internal wiring.**

**Figure 8. Item #3, circuit board.**

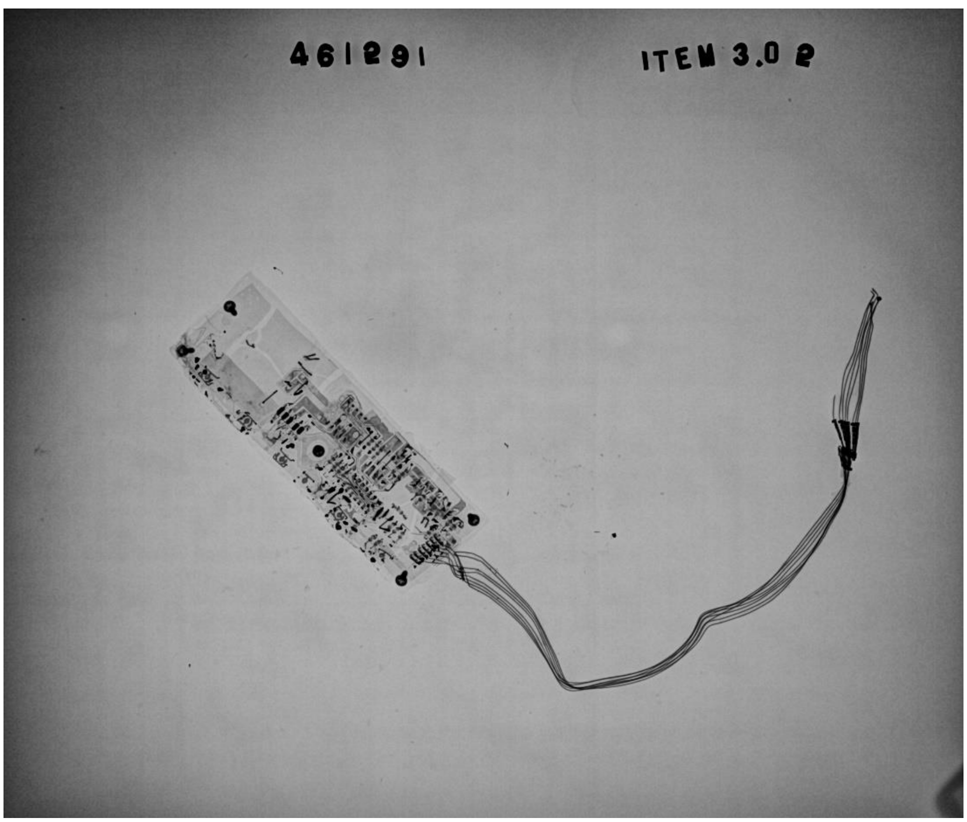



**Figure 9. Item #3, circuit board x-ray.**

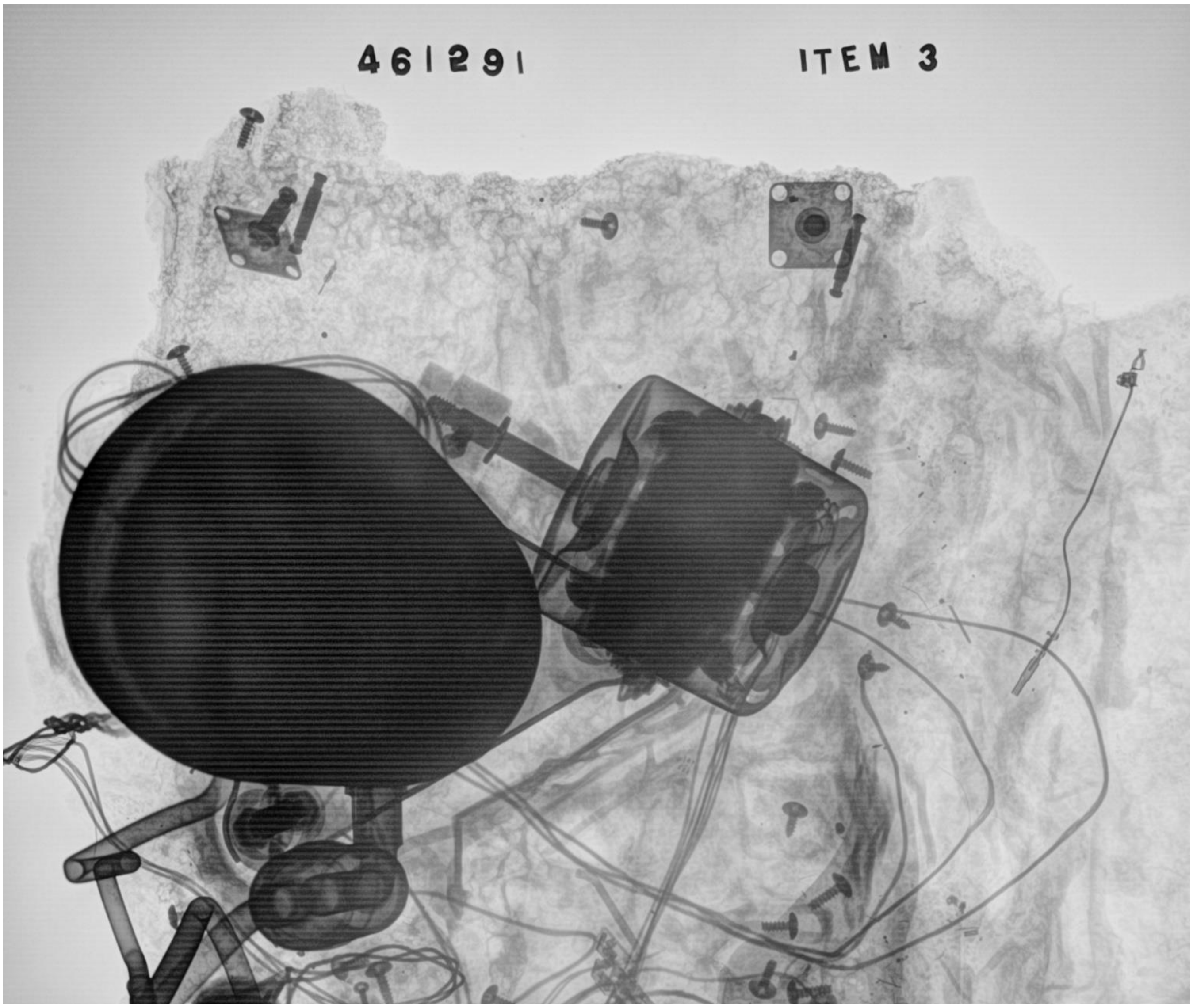



**Figure 10. Item # 3 dehumidifier x-ray.**

### 4.3 The Norcold Absorption Refrigerator

**4.3.1** Jensen Hughes performed the following tasks on the Norcold refrigerator.

**4.3.2** Visually examined and photographically documented the remnants of the subject Norcold refrigerator (Item #1) in their as-received condition, as seen in Figures 11 and 12.

**4.3.3** Visually examined and photographically documented the boiler regions of the subject Norcold refrigerator in its as-received condition (Figures 13 through Figure 15).

**4.3.4** Performed a leak test on the boiler/condenser system of the subject Norcold refrigerator, using air pressure and non-corrosive leak detection solutions (soap solution, alcohol) to determine the location of any perforations, shown in Figure 16. Figure 17 is a photograph

of a perforation site, made visible via the bubbles during the pressure test. The perforation was observed on the boiler tube. Figure 18 is a photograph of the weldment area in the boiler assembly with the perforation site outlined in yellow.

**4.3.5** Removed the boiler assembly from the subject refrigerator to facilitate examination and further sectioning (Figure 19). Sectioned the boiler tube and removed heating elements (Figure 20 and Figure 21).

**4.3.6** Visually inspected and photographically documented the inner surface of the sectioned tubing (Figures 22 and 23).

**4.3.7** Further sectioned the tubing to isolate perforations to permit mounting in cold-set epoxy (Figure 24).

A second destructive evidence examination was performed on July 28, 2021, with representatives for the Compass Insurance Company, Norcold and Essentia Insurance Company. Jensen Hughes performed the following tasks:

**4.3.8** The mounted sample was ground and polished to a metallographic finish and etched with a 2% Nital solution to reveal grain structure (Figure 26).

**4.3.9** Microscopically examined and documented the metallographic sample using a digital optical microscope, shown in Figures 27 and 28.

**Figure 11. Item #1, described as "Norcold Refrigerator."**

**Figure 12. Item #1, described as "Norcold Fridge Components" which included various metallic parts, electronic components and conductors.**

**Figure 13. Item #1, the boiler assembly of the subject Norcold refrigerator. The pigtail coming off the absorber tank (circled in red) identified this refrigerator as being manufactured by Norcold.**

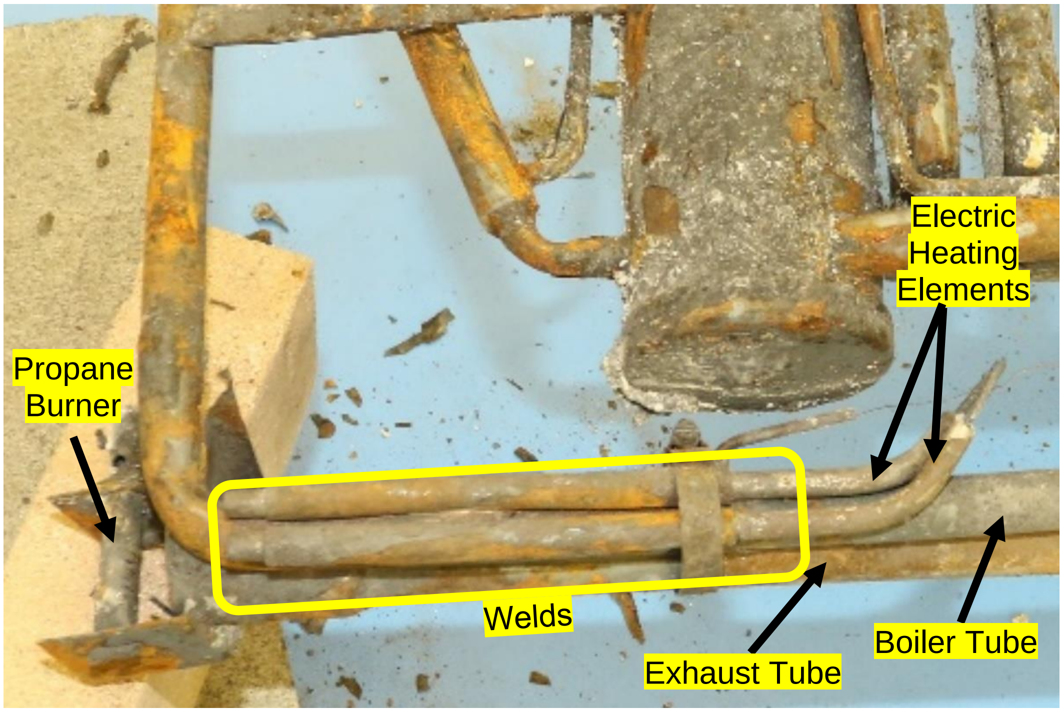



**Figure 14. Item #1, enlarged view of the boiler assembly.**

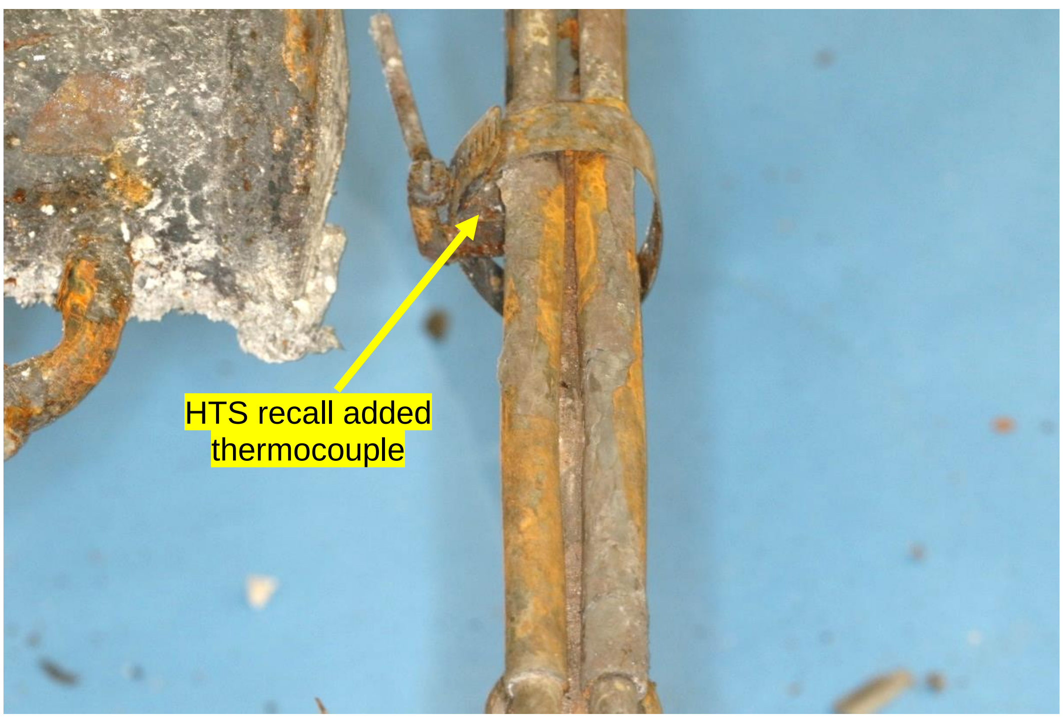



**Figure 15. Item #1, the HTS recall thermocouple installation of the subject Norcold refrigerator.**

**Figure 16. Item #1, pressure testing of boiler tube.**

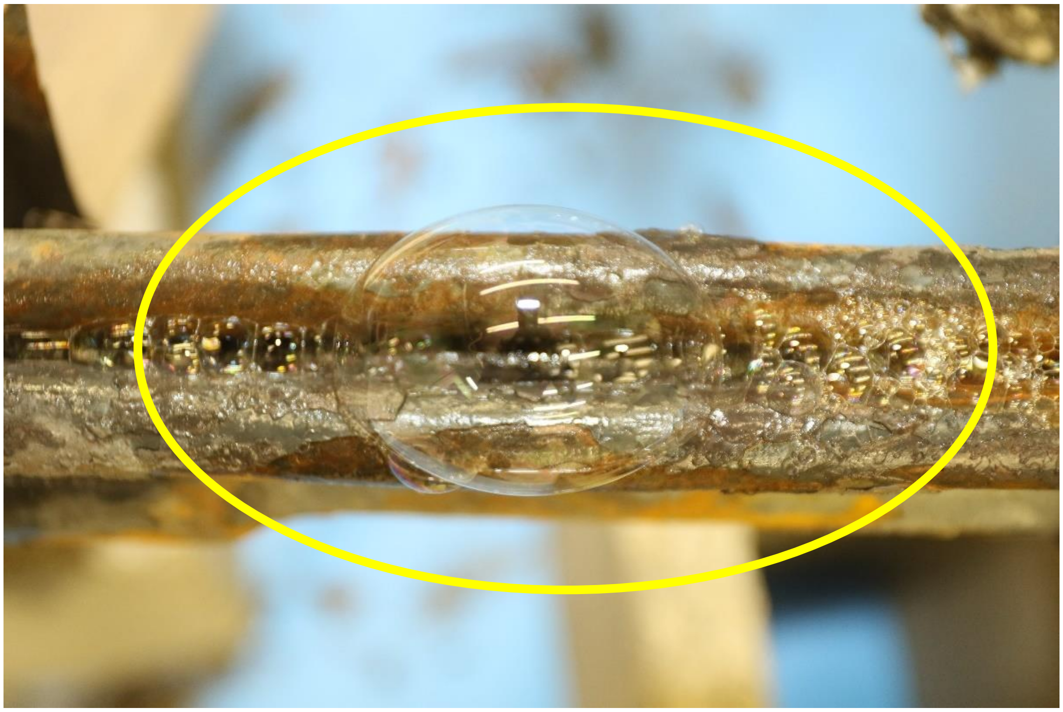


**Figure 17. Item #1, enlarged photograph of boiler tube with bubbles at location of leak.**

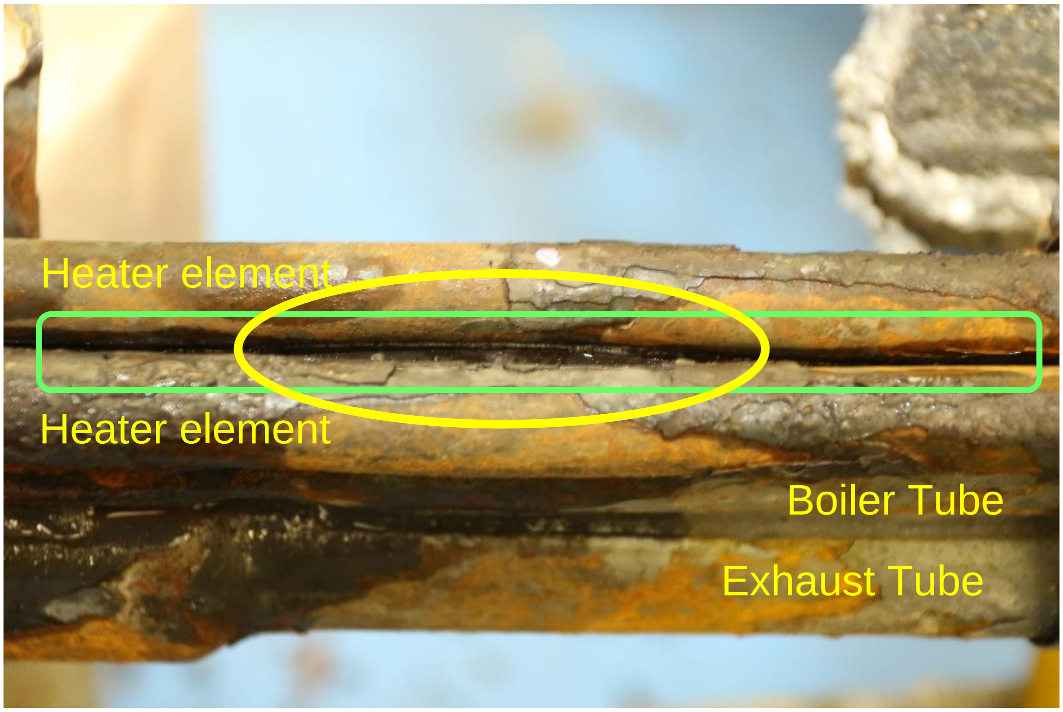



**Figure 18. Item #1, photograph of the weld area of the subject boiler assembly. The welds are noted with a green box.**

**Figure 19. Item #1, photograph of the boiler assembly after being removed from the subject refrigerator.**


**Figure 20. Photograph of Item #1.01, 1.02, 1.03, 1.04, 1.05, 1.06, and 1.07, after sectioning of Item #1.**


**Figure 21. Item #1, photograph of the two halves of the boiler tube after sectioning.**

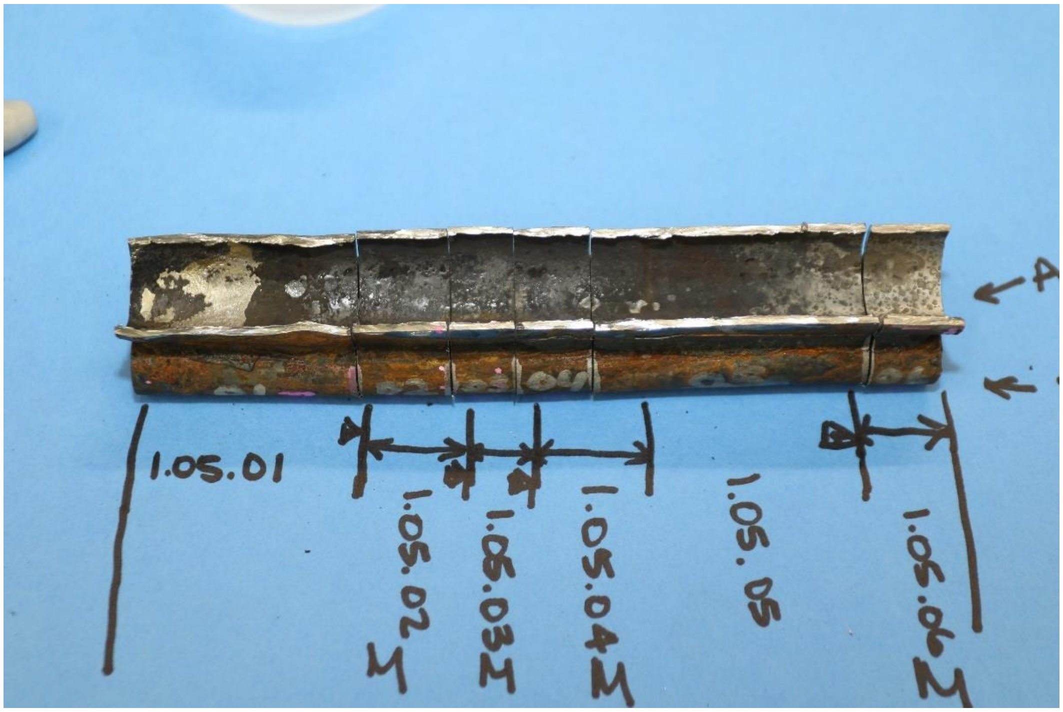



**Figure 22. Item #1.05 and its associated sub-sections, photograph of the inner surface of the boiler tube at the perforation site.**

**Figure 23. Item #1, enlarged view of tubing interior surface. The yellow arrow highlights an internal crack that progressed through the steel boiler tube and allowed flammable refrigerant to escape the boiler tubing.**

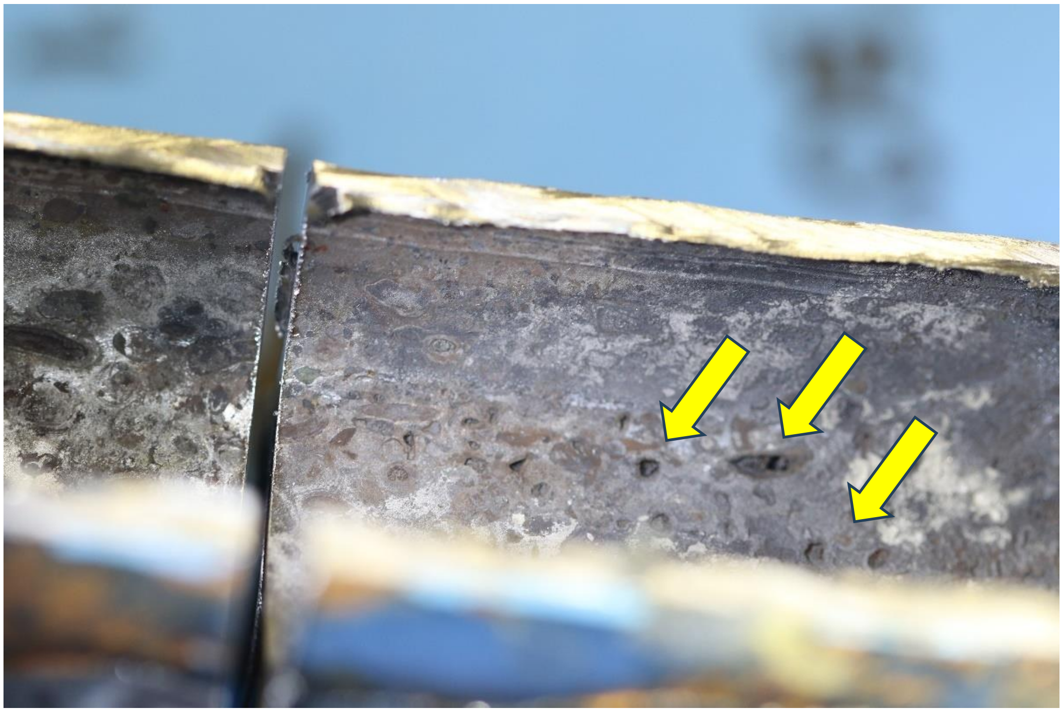


**Figure 24. Item #1, enlarged view of pitting corrosion found inside tubing.**

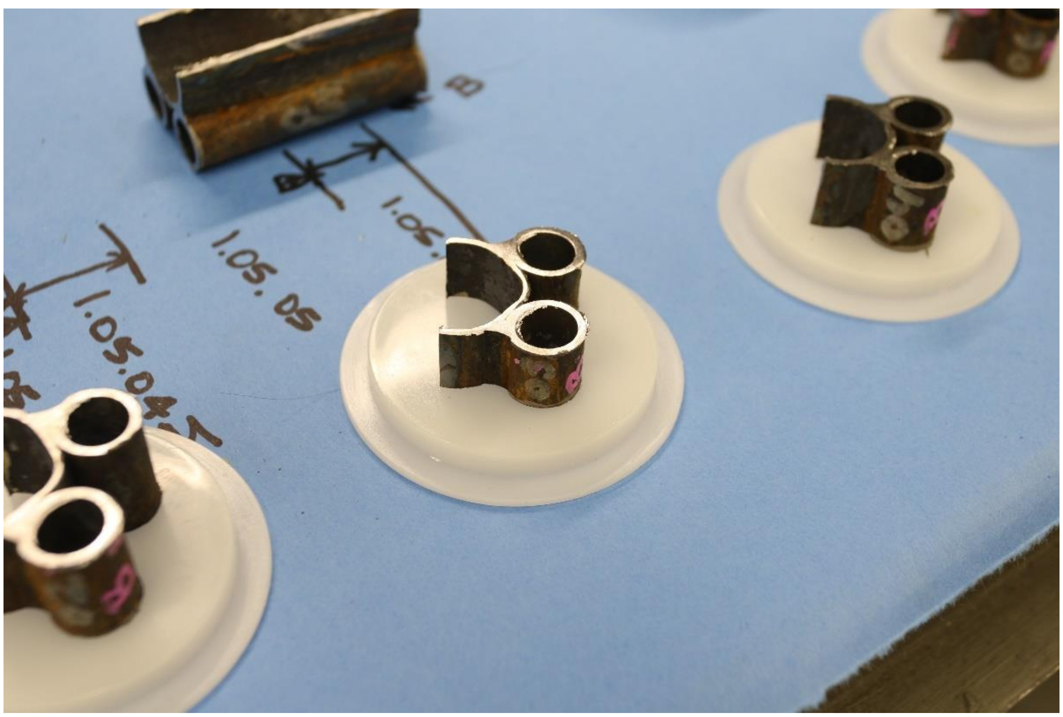



**Figure 25. A photograph of the boiler tube after being sectioned to create metallographic mounts.**


**Figure 26. Tubing sections produced from Item #1.05 after cutting and mounting.**

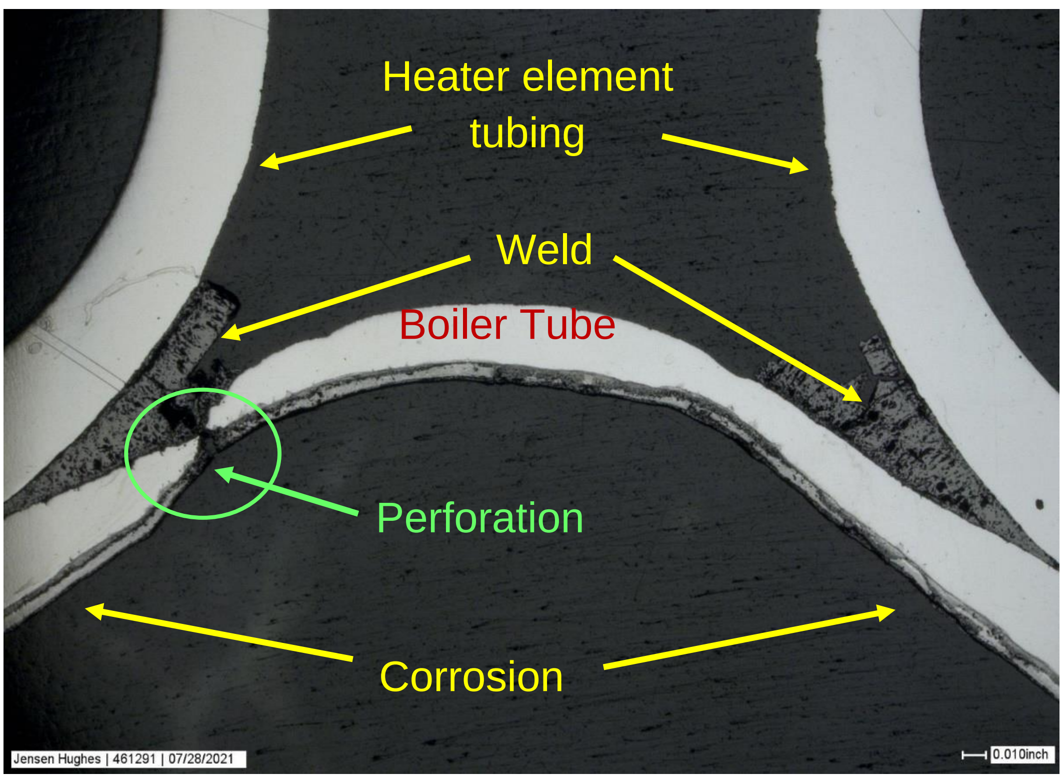



**Figure 27. Item #1.05.03, optical micrograph of the mounted boiler tube section. The perforation shown in green lettering allowed flammable refrigerant to escape into the motorhome.**

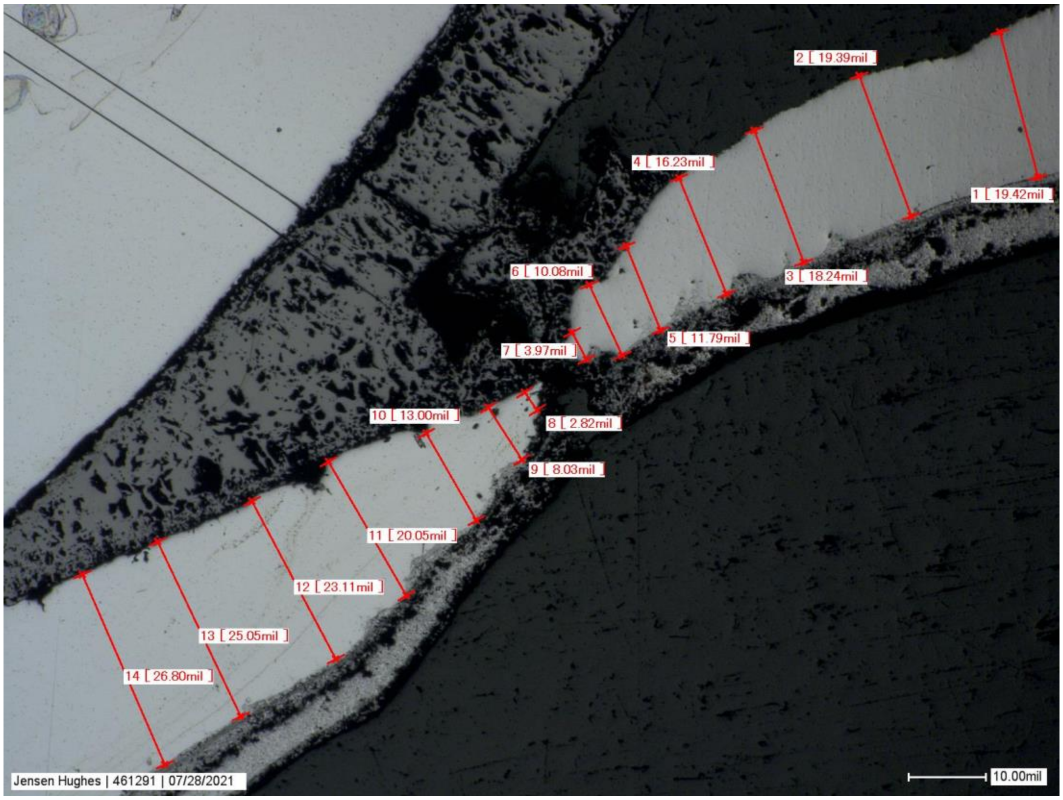



**Figure 28. Item #1.05.03, optical micrograph of the mounted and perforated boiler tube section.**

### 4.4 Absorption Refrigerator System Operation

The refrigeration process operates in a closed system by heating an ammonia and water solution in the boiler region, which is referred to as a "strong ammonia solution." The heat to the system is applied by either electric heaters or through hot gases from the propane burner which then rise through the flue tube. The heat circulates the ammonia refrigerant around the cooling tubes (see Figure 29 below).

Both the electric heaters and the flue tube are attached to the boiler tube by single fillet welds. All other heat necessary to run the refrigeration cycle is transferred through these welds to the cooling solution inside the cooling unit. In the "vapor pump," ammonia gas separates from water and rises to the rectifier. The ammonia gas flows to the condenser and condenses into pure ammonia liquid.[1] The liquid ammonia flows to the evaporator where the liquid returns to a gas. The transition from liquid ammonia to gaseous ammonia removes heat from the system. The gaseous ammonia is re-absorbed into the water solution and the process starts anew. In the boiler region, the water that returns to the absorber is considered to be a "weak ammonia solution." Hydrogen gas is added to the ammonia-water solution to permit the liquid ammonia to evaporate.

The refrigerant present in the absorption system is a mixture of ammonia, water, hydrogen, and sodium chromate. The chromate provides corrosion resistance to the steel boiler tubing from the corrosive ammonia/water solution. Corrosion resistance wanes when the chromate corrosion inhibitor has been consumed and is no longer available to protect the steel.

The refrigerator cooling units are pressurized to 350 psi during manufacture. The typical operating pressure of the absorption system is approximately 430 +/- 15 to 25 psi. The external temperature of the boiler tube can reach

[1] Althouse, A., Turnquist, A., and Bracciano, C., *Modern Refrigeration and Air Conditioning*, 1996.

temperatures as high as 400 +/- 30 °F. When the fluid has leaked, leaving the boiler dry, the boiler tube can reach temperatures of 1,200°F.

Both hydrogen and ammonia are present in the cooling unit. Hydrogen is an extremely volatile gas that has a reported autoignition temperature of 932 °F in the range of 4 – 75% concentration in air1. Hydrogen can spontaneously ignite if quickly released from a compressed state, and can be ignited by static electricity.[2,3] When a competent ignition source is present, such as an electrical arc, liberated hydrogen gas from a container may be ignited. Anhydrous ammonia ($NH_3$) is a flammable gas and will ignite at temperatures above 1204 °F in the range of 15 – 28% concentration in air.

### 4.5 Subject Refrigerator

Norcold has determined that the root cause of boiler tube leaks is internal corrosion, most often at or near the heat affected zone (HAZ) of a boiler tube weld or at an internal failure of a weld along the heating element. The refrigerant released by a leak can be easily ignited, and knowledge of this hazard has caused Norcold and other absorption-style refrigerator manufacturers to issue multiple recalls with the National Highway Transportation Safety Administration (NHTSA).[4,5] The fracture in the subject refrigerator's boiler tube was small and localized in the bottom of the refrigerator, near the electric heating elements, typical of a pre-fire, corrosion-related boiler tube leak.

A leak test with air (a gas) was conducted during this investigation (Figure 16 and 17) in order to **identify** the post-fire perforation site and **only for this reason**. This leak test was not intended to try and mimic the pre-fire conditions of leaking refrigerant at the perforation site. The scientific reasons for this are multiple:

- The viscosity of air (a gas) is not equivalent to the viscosity of the refrigerant (a liquid/gas mixture).
- The initial, incipient crack that led to the release of refrigerant was likely **much smaller** than the post-fire perforation site.

Norcold references the use of a 1010 carbon steel for boiler tubing in their documentation. The refrigerant used by Norcold is incompatible with low-carbon steel as referenced in many journals and acknowledged by Norcold. Sodium chromate and water are added to the refrigerant as corrosion inhibitors. The subject boiler tube experienced uniform corrosion, which attacked a large area of the inner surface of the boiler tube, as opposed to localized corrosion, which would result in small corrosion pits. The corrosion developed and progressed in the boiler region due to the application of heat to the steel, which accelerated the rate of corrosion.

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[2] Xu, B. et al, "Numerical study on the spontaneous ignition of pressurized hydrogen release through a tube into air," *Journal of Loss Prevention in the Process Industries*, vol. 21, issue 2, March 2008, pp. 205-213.

[3] http://www.hysafe.org/BRHS

[4] Dometic Defect and Noncompliance Notice, NHTSA Campaign Number 06E076000, August 28, 2006

[5] Dometic Defect Notice, NHTSA Campaign Number 08E032000, April 11, 2008

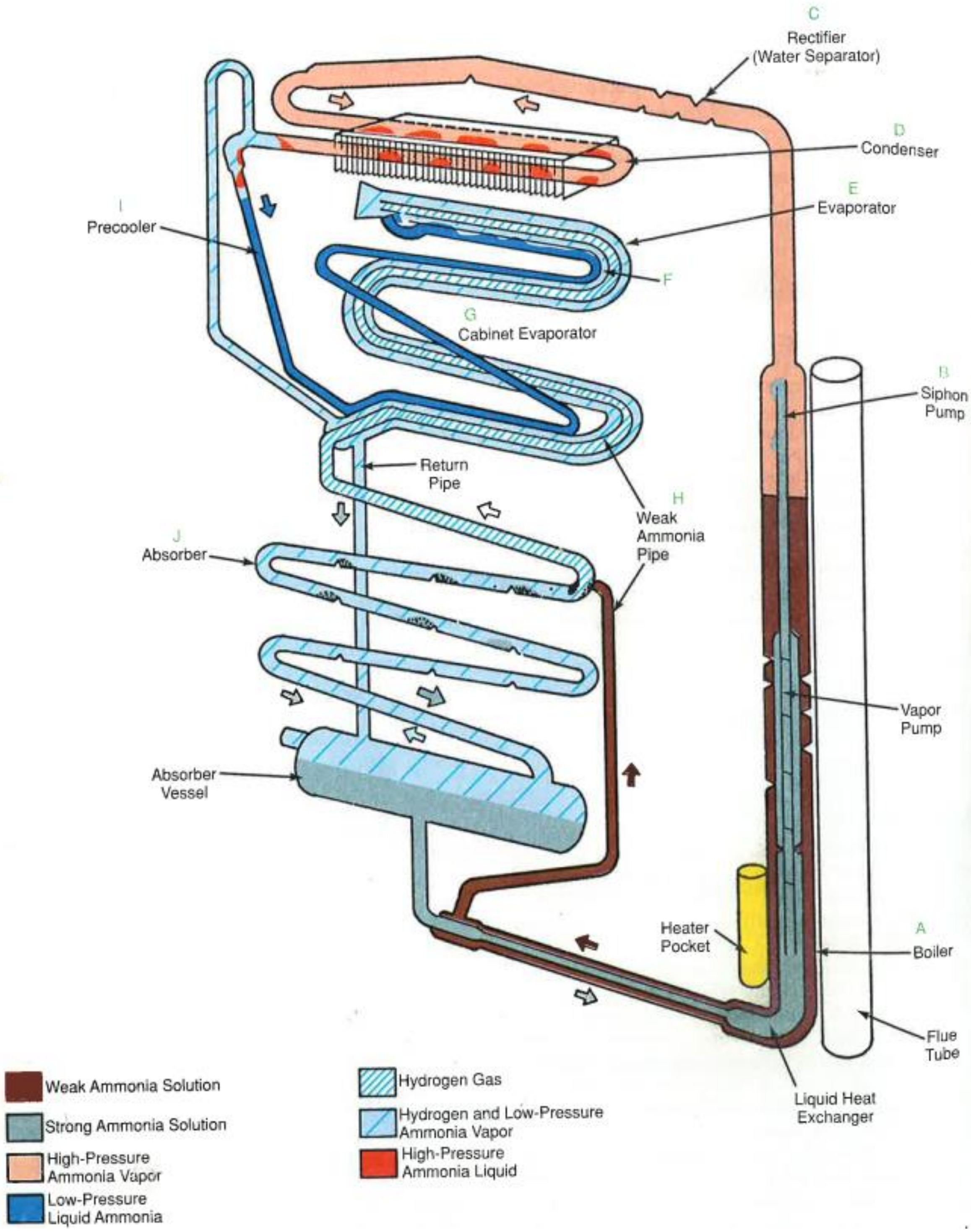


**Figure 29. Diagram of an absorption refrigerator, from Althouse, A., Turnquist, A., and Bracciano, C., *Modern Refrigeration and Air Conditioning*, 1996.**

The cause of the corrosion cannot be determined with certainty, since the quantities of refrigerant and corrosion inhibitor that existed prior to the fire were lost when the boiler tube initially leaked and during the subsequent fire. However, corrosion inside boiler absorption tubes could only be the result of either oxygen contamination, a shortage of corrosion inhibitor or the designed thickness of the steel boiler tube, which lowers the life expectancy of the refrigerator. Regardless of the specific reason why the failure occurred, all of these issues caused an internal corrosion leak and were the result of choices made by Norcold during the manufacture of the subject refrigerator and no other entity.

A measurement (as seen in Figure 28) taken in a less-corroded area of the boiler tube show a tube wall thickness of approximately 0.027 inches (26.8 mils), which demonstrates material loss from the original 0.047-inch boiler tubing wall thickness specified by Norcold. A single perforation was documented and encapsulated into a metallographic mount. At the perforation, wall thickness had been reduced to less than 0.003 inches (2.82 mils) at the crack tip, resulting in a loss of approximately 93% of the original wall thickness.

Low-carbon steel, like that used in the boiler tube (1010), has a tensile strength of approximately 56,000 psi and a yield strength of approximately 41,000 psi.[6] A simple hoop-stress calculation showed that at a yield strength of 41,000 psi and a wall thickness of 0.002 inches, an internal pressure of approximately 300 psi would cause the metal to yield and tear.[7] The calculated pressure of 300 psi is within the range of the normal operating pressure in the boiler system, therefore the metal likely failed during normal operation and prior to the fire.

The calculated pressure of 300 psi is substantially less than the 430 psi normal operating pressure when the boiler is being heated. While at rest and not being heated, the unit should maintain the original charge pressure of 350 psi, introduced at the onset of manufacturing. Therefore, two conclusions about when the failure occurred can be drawn. One, the metal likely failed while the refrigerator was at rest (and not while the heat was being applied, as it would be during a cooling cycle). Two, most certainly, the failure in the boiler tube wall DID NOT occur during a fire (which may have been caused by some other source within the RV). Some Norcold experts have offered that failure of the boiler tube occurs when the refrigerator was engulfed by an ensuing caused by another source. If this were to happen, the pressures in the boiler tube would have been extremely high and would have resulted in a much thicker cross-sectional failure of the steel tube, not 0.002 of an inch that was found. Therefore, the failure and leak of the boiler tube is consistent with end of life due to localized corrosion that allowed flammable gases to leak and become ignited, and not the victim of some other fire.

A Norcold metallurgical expert has opined equivalently with Jensen Hughes findings regarding the inherent design defect and end-of-life corrosion issue in these units:[8]

> *2. Corrosion thinning of the boiler tube wall during operation is the typical mode of material deterioration over time of a gas absorption refrigerator cooling unit.*
>
> *3. Thinning of the boiler tube wall such that the pressurized boiler can no longer sustain normal operational pressures is the common end of life failure mode of a gas absorption refrigerator cooling unit.*

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[6] ASM International, *Concise Metals Engineering Data Handbook*, Chapter 9: Mechanical Properties of Metals and Alloys

[7] Roark and Young, Formulas for Stress and Strain, Fifth Edition, 1975, p. 448

[8] Exhibit C - Report of Jamie L. Petty-Galis, dated October 30, 2023 in Marx v. Norcold

# 5.0 OPINION AND BASES

Conclusions stated in this report are expressed on a more probable than not basis to a reasonable degree of engineering and scientific probability and are based on the ongoing investigation conducted by Jensen Hughes (Scott Roberts, Jonathan Contreras and Jeff Marsh). We reserve the right to amend this report or provide a supplemental report as new information becomes available.

**5.1 Opinion: The origin of the fire was at the 2006 Monaco motorcoach, Diplomat 40PAQ.**

**5.1.1 Basis:** Per National Fire Protection Association (NFPA) *921Guide for Fire and Explosion Investigations* 2021, the burn patterns show that the fire emanated from the RV as opposed to other areas in the building.

**5.1.2 Basis:** According to information from the Snohomish County Deputy Fire Marshal Dan Lorentzen, the first witness to observe the fire and who called 911 reported seeing the fire within the area of the RV. Mr. and Mrs. Phillips went outside and observed flame penetration through the roof of the new garage addition where the motorcoach was parked. Mr. and Mrs. Phillips, both moved towards the west side of the new addition and reported they observed that the bulk of the fire was where the motorcoach was parked.

**5.1.3 Basis:** Mr. Phillips described having issues with the refrigerator on the evening before the fire. He stated he went into the motorcoach around 7:00 PM to drain water from the dehumidifier unit which was performed every 2-3 days. Upon his entrance into the motorcoach, he heard the motorcoach refrigerator beeping and observed the refrigerator's control panel flashing, indicating an error. He opened the refrigerator door and observed the interior light did not energize. On the refrigerator, he pressed the OFF button followed by the ON button, and the refrigerator started up again. The refrigerator stopped beeping and appeared to be operating normally. The refrigerator mode was originally set to "Auto" and he changed the mode to "AC" and then left the RV.

**5.1.4 Basis:** NFPA 921 asks investigators to consider "fire dynamics" when considering the origin of the fire. In this matter, we have considered alternate hypotheses for the origin of the fire. Based on the witness accounts and fire patterns, the fire likely originated within the RV. From a fire aspect, the RV provides a large fuel source and would explain why the fire spread from the center of the building outward. We also know that the RV had three operating heat sources capable of igniting the fire. We considered the multiple hypotheses that the fire originated from the refrigerator, the dehumidifier or the radiant heater Collectively, Jensen Hughes has investigated many fires that have started within absorption refrigerators produced by Norcold and others, and we know absorption refrigerators have the ability to start and spread fires within recreational vehicles, which was why they were recalled.

**5.1.5 Basis:** The first fuel for the fire was likely the escaping flammable gases from the refrigerant within the boiler section of the absorption refrigerator. The gases are gaseous ammonia and hydrogen, both of which are flammable. Secondary fuel sources were the wood framing of the refrigerator cabinetry surrounding the refrigerator. The fire likely spread from the back of the refrigerator once the escapes gases ignited, up and into the wooden cabinetry and into the ceiling of the motorcoach.

**5.2 Opinion: The GE Dehumidifier was eliminated as the source of the fire.**

**5.2.1 Basis:** No electrical arcing was identified within the dehumidifier that would indicate that it was capable of starting the fire.

**5.2.2 Basis:** The radiographic examination of the dehumidifier did not reveal any evidence of the anomalous electrical activity within the product.

**Basis:** Since no evidence of electrical failure of the dehumidifier was found, the dehumidifier was eliminated as a probable cause of the fire.

**5.3 Opinion: The Delongi oil-filled radiant heater did not start the fire.**

**5.3.1 Basis:** No electrical arcing was identified within the dehumidifier that would indicate that it was capable of starting the fire.

**5.3.2 Basis:** The radiographic examination of the dehumidifier did not reveal any evidence of the anomalous electrical activity within the product.

**Basis:** Since no evidence of electrical failure of the dehumidifier was found, the dehumidifier was eliminated as a probable cause of the fire.

**5.4 Opinion: A leak of flammable refrigerant occurred in the Norcold 1200 model refrigerator prior to the fire on January 28, 2021. This leak was the cause of the fire and not the result of the fire.**

**5.4.1 Basis:** The crack in the boiler tube was caused by an internal uniform corrosion process that deteriorated the thickness of the boiler tube wall. The boiler tube wall became so thin that the normal operating pressure was sufficient to create a small crack (perforation). An analysis using the material's yield strength revealed that an operating pressure in the range of 300 – 375 psi was likely sufficient to cause a crack.

**5.4.2 Basis:** As the unit is charged with 350 psi at the onset of manufacture, it likely that the subject perforation occurred while the refrigerator was at rest, not in a cooling cycle (and therefore not being heated), and not being attacked by an outside fire.

**5.4.3 Basis**: The internal corrosion was caused by a combination of heat, insufficient anti-corrosion agent, and plain carbon steel being susceptible to corrosive attack.

**5.5 Opinion: A refrigerant leak from a Norcold absorption-style refrigerator can cause a fire.**

**5.5.1 Basis:** The refrigerant was comprised of ammonia, hydrogen, water and sodium chromate. Both the ammonia and the hydrogen are flammable gases

**5.5.2 Basis:** If the contents of the refrigerant are not contained within the boiler tube and are present in sufficient quantity near a competent ignition source, then a fire can occur.

**5.5.3 Basis:** Norcold acknowledges that fires can occur from the expelled refrigerant contents. The Owner's manual and the Installation manual warn that if the refrigerant is released and ignited, it can burn with an "intense flame."

**5.5.4 Basis:** Since components of the refrigerant are flammable gases at standard temperatures and pressures, only a small ignition source is necessary to ignite the gases. Ignition sources will include (but not be limited to): electrical arcing, parting and closing arcs, static discharge, hot surfaces, chemical reactions, mechanical friction, etc.

**5.5.5** **Basis:** Norcold recalled these refrigerators five (5) times. Norcold manufactured an HTS (high temperature sensor) kit that was designed to shut off the refrigerator if the boiler exceeded a preset temperature. It is possible that this device may have acted as the ignition source if it stopped the flow of power to the refrigerator. This device does not appear to meet the requirement of NFPA 70 for explosion proof enclosures.

**5.5.6** **Basis:** The hazard presented by the flammable gases escaping a leak in the boiler tube is not eliminated by the interruption of power to the refrigerator. Escaping flammable gases may still find an ignition source near the source of the leak. Even if the HTS kit had acted as designed and disabled power to the failed refrigerator, there were still other competent ignition sources present nearby which could act to ignite the escaping flammable gases.

**5.5.7** **Basis:** Jamie L. Petty-Gallis, a metallurgical expert hired by Norcold on multiple occasions has acknowledged that degrading corrosion occurs within the boiler tubing and has opined in other cases that a corrosion-driven perforation of the boiler tubing is a common “end-of-life” scenario for these refrigerators. When these perforations occur, flammable gases will be expelled from the refrigerator.

**5.5.8** **Basis:** Once the leaking refrigerant is ignited, the fire will progress up the back of the refrigerator and into the living quarters. Jensen Hughes has examined many absorption refrigerators fires, including those produced by Norcold. Figure 30 below is a photograph taken of a Norcold 1200LRIM refrigerator. This refrigerator was involved in a Jensen Hughes case referred to as the Baird fire, and occurred in Missoula, MT. The refrigerator was examined and pressure tested. During leak testing it was discovered that the boiler had developed a leak. The fire was confined to the back of the refrigerator. The insurance claim in this case was resolved by Norcold with the owner’s insurance company before destructive testing could occur. This photograph depicts the typical burn pattern observed on failed absorption refrigerators emanating from the lower right portion of the back of the refrigerator (the area of the boiler tube) and spreading upward. This is one case of many that Jensen Hughes has investigated which involved a fire caused by an absorption refrigerator.

**Figure 30. A photograph of the Baird refrigerator, Norcold 1200LRIM. The fire originated in the rear of the refrigerator and spread upward. The red circle shows the origin of the leak and subsequent fire, which was at the electric heating elements. The red lines show the direction and spread of the fire from the back of the refrigerator.**

**5.6 Opinion: The Norcold HTS Kit 634737 will not detect and prevent a leak of the refrigerant, and therefore will not prevent all fires caused by a leaking boiler tube.**

**5.6.1 Basis:** The HTS kit only measures temperatures of the thermocouple block. If the temperature of the thermocouple block exceeds a preset temperature, the control module for the HTS kit will discontinue the supply of electrical power to the refrigerator. In order for the thermocouple device to activate and shut down electric power to the refrigerator, the refrigerant temperature has to exceed the preset limit, which only occurs when refrigerant flow to the boiler tube has been interrupted, as with a boiler tube leak. Therefore, the thermocouple only shuts down the unit after a leak occurs, which fails to prevent flammable gases from being expelled by the refrigerator. This does not prevent the leak from occurring; it only attempts to eliminate the components on the failed refrigerator as an ignition source.

**5.6.2** **Basis:** The cause of this fire was a leak of flammable gases from the cooling unit boiler tube of the refrigerator. Electronic controls for the refrigerator, surrounding controls for other equipment, wiring connections, and a host of other potential ignition sources are present and could have ignited the flammable gases.

# 6.0 QUALIFICATIONS OF THE AUTHORS

JENSEN HUGHES

**JEFFREY MARSH** CFEI
SENIOR ELECTRICAL ENGINEER

*Education*

BS, Electrical Engineering Technology, Purdue University, 1997

*Certifications*

Certified Fire and Explosion Investigator (CFEI), National Association of Fire Investigators (NAFI)

*Associations*

Member, National Association of Fire Investigators (NAFI)

Member, National Fire Protection Association (NFPA)

## *Bio*

Jeffrey's experience includes working in electrical/mechanical failure analysis, electrical design/build contracting, electrical installation and automotive manufacturing environments. He is recognized as a Certified Fire and Explosion Investigator (CFEI) by the National Association of Fire Investigators (NAFI). He has composed legal declarations for class action lawsuits, served as an expert witness in civil court and is familiar with insurance claim losses. His investigative casework experience includes product failure analysis, electrical cost estimating for residential, commercial, and industrial properties, fire investigations for residential, commercial, industrial and marina properties, failure analysis for low and medium voltage utility distribution transformers, electrical control systems and electrical/mechanical equipment. He uses computerized analysis and CAD tools to document projects and designs, including AutoCAD, Programmable Logic Controller (PLC) Programming, Visual Lighting Design Software and Estimating Software: ConEst, Accubid, McCormick, and RS Means.

Jeffrey has managed product quality internationally, including the manufacturability of electronic components for vehicle manufacturers. He has performed damage assessments and remediation consulting on national and international electrical infrastructures.

## *Project Highlights*

SENIOR ELECTRICAL ENGINEER, JENSEN HUGHES, INC., 2018-PRESENT

Specializes in electrical fire cause and origin, electrical system failures, solar electric power systems, manufacturing and automated control system failures, electrical and electronic product analysis and testing, ground system and soil resistivity testing, and engineering consulting on electrical system design, analysis, and remediation. Conducts appliance and product fire and failure investigations. Addresses personal injuries related to electricity and electrical equipment failure.

*Contact*

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## Professional Highlights, Continued

### PROJECT CONSULTANT, ENVISTA FORENSICS, 2013-2018

Performed investigation and analysis of failures involving equipment, systems and workmanship. Casework included CSST failures, HVAC and boiler equipment failures, lightning damage, electrical fires, water exposed electrical equipment, underground electrical installation failures, fire and water remediation, elevator equipment, generator and automatic transfer switch failures, low- and medium-voltage transformer failures, and electrical cost estimating. Developed protocols and performed laboratory product testing.

### ELECTRICAL DESIGNER / ESTIMATOR, EOFF ELECTRICAL CONTRACTOR, 2011-2013

Increased sales revenue by developing new customer relationships while providing customer-focused designs, cost-effective estimates, and accurate cost control.

### SELF-EMPLOYED, INDIANAPOLIS, IN, 2009-2011

Contracted consulting and estimating services to local electrical contractors. Assisted in the installation and testing of electrical equipment, including bus duct, control devices, conduit, and wire. Performed cost analysis for the installation of electric vehicle charging stations.

### PROJECT MANAGER, CREW TECHNICAL SERVICES, 2009

Performed project management while restructuring the estimating and project management operations.

### ESTIMATOR, MILLER EADS ELECTRICAL CONTRACTOR, 2008-2009

Provided estimates for over $15 million of large commercial and industrial projects, including wastewater treatment plants, manufacturing plants, warehouses, hotels, and schools.

### ELECTRICAL CONTRACT MANAGER, GLOBAL PERFORMANCE, 2006-2008

Managed electrical contract work for the design and construction of a new automobile manufacturing plant on a greenfield construction site of more than 1,700 acres. Responsible for electrical design review, including site electrical and lighting systems, fire alarm systems, building electrical distribution and lighting systems and emergency lighting and power systems.

### ELECTRICAL PROJECT MANAGER/DESIGNER, ENTERPRISE ELECTRICAL & MECHANICAL, 2005-2006PE

Managed and designed electrical and lighting systems for large commercial projects.

### CONTROLS ENGINEER / MAINTENANCE SUPERVISOR, ALLISON TRANSMISSION, 1997-2005

Supervised preventative maintenance of the facilities and the manufacturing machinery. Designed, implemented and performed failure analysis on automated equipment control systems. Managed the quality and manufacturability of electronic components at international manufacturing facilities.

## Notable Publications + Presentations

### PUBLICATIONS, TECHNICAL JOURNALS + BOOKS

Marsh, J., "Investigating SCADA System Claims," PTC|LWG Consulting Webinar Series, Seattle, WA, 2016

Marsh, J. and Vandal, B., "Power Surges & Utilities: What causes them and how they differ from lightning," Oregon Claims Adjusters Association (OCAA), Monthly Luncheon, Portland, OR, 2016

## *Professional Standings*

### CONTINUING EDUCATION + TRAINING

+ Evidence Examination: What Happens at the Lab? CFI Trainer.net, 2018
+ Wildland Fires Investigation, CFI Trainer.net, 2018
+ Ethics and the Fire Investigator, CFI Trainer.net, 2018
+ Documenting the Event, CFI Trainer.net, 2018
+ Electrical Safety, CFI Trainer.net, 2018
+ Writing the Initial Origin and Cause Report, CFI Trainer.net, 2018
+ Digital Photography and the Fire Investigator, CFI Trainer.net, 2018
+ Basic Electricity, CFI Trainer.net, 2018
+ Residential Electrical Systems, CFI Trainer.net, 2018
+ Physical Evidence at the Fire Scene, CFI Trainer.net, 2018
+ Asbestos Awareness Training, Safety Unlimited Inc., 2018
+ Arc Mapping Basics, CFI Trainer.net, 2018
+ Thermography Training, Envista Forensics, 2017
+ Respiratory Safety, PTC|LWG Consulting, 2016
+ Hazard Communication, PTC|LWG Consulting, 2016
+ Electrical Safety, PTC|LWG Consulting, 2016
+ Certified Fire and Explosion Investigator, NAFI, 2016
+ CSST Fire Investigation Claims: What you need to know, PTC|LWG Consulting, 2016
+ Electric Car Charger, PTC|LWG Consulting, 2016
+ Slips Trips and Falls, PTC|LWG Consulting, 2015
+ Safety-Asbestos Awareness, PTC|LWG Consulting, 2015
+ Restoration & Medical Equipment, PTC|LWG Consulting, 2015
+ The Application of Expert Engineering Knowledge to Complex Losses, 2015
+ Overcurrent Protection of Conductors, PTC|LWG Consulting, 2015
+ To Re-wire or Not to Re-wire: Damaged Building Infrastructure? PTC|LWG Consulting, 2015
+ Safety-Fall Protection, LWG Consulting, 2014
+ Ladder Safety, LWG Consulting, 2014
+ Lockout/Tagout-Safety, LWG Consulting, 2014
+ PPE-Safety, LWG Consulting, 2014
+ Elevator & Escalator Claims: Investigating the Damage, LWG Consulting, 2014
+ Don't Get Blown Away: Equipment Failures Related to Wind Energy, LWG Consulting, 2014
+ Food Processing Facility Losses, LWG Consulting, 2014
+ Strategies for Successful Handling of Agriculture Equipment Losses, LWG Consulting, 2013
+ Investigating Appliance Fires, LWG Consulting, 2013
+ Remote Control and Signaling Circuits, LWG Consulting, 2013
+ Adjusting Lightning Damage Losses, LWG Consulting, 2013

## *Professional Standings, Continued*

### CONTINUING EDUCATION + TRAINING, CONTINUED

- Troubleshooting & Servicing Electric Furnaces, LWG Consulting, 2013
- Grounded Systems, LWG Consulting, 2013
- Installing Motors and Transformers, LWG Consulting, 2013
- Job Site Safety, LWG Consulting, 2013

Allen Bradley Programmable Logic Control (PLC) Programming, Rockwell Automation,

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## JONATHAN CONTRERAS PE

SENIOR METALLURGICAL + MATERIALS ENGINEER

### Education

MS, Metallurgical and Materials Engineering, The University of Texas at El Paso, 2012

BS, Metallurgical and Materials Engineering (Magna Cum Laude), The University of Texas at El Paso, 2009

### Registrations

PE: CA, MI, WA

### Languages

Spanish (Fluent)

### Bio

Jonathan conducts forensic and failure analysis investigations and provides metallurgical consulting services for clients in the automotive, aerospace, construction, oil and gas, military, mining, manufacturing, and power generation industries. He provides root-cause failure analysis supported by non-destructive analyses, photographic documentation, chemical composition analyses, mechanical testing, metallographic analyses, fractographic analyses, and SEM/EDS/FTIR/TGA/CT analyses. His skills include digital photography, component sectioning methodologies, forensic analysis protocols (laboratory and field), metallographic sample preparation, scanning electron microscope sample preparation, and macro- and micro-hardness testing. His expertise also includes the operation of optical metallographs, operation of stereomicroscopes, operation of optical emission spectrometers, and operation of scanning electron microscopes with energy-dispersive analysis capabilities.

### Professional Highlights

SENIOR METALLURGICAL + MATERIALS ENGINEER, JENSEN HUGHES, INC., 2022-PRESENT

Performs failure analysis, materials characterization, metallurgical testing, microstructure evaluation and characterization for commercial, industrial and residential occupancies. Supports fire investigations via analysis of electrical conductors. Conducts weld examination and analysis. Evaluates failures of pressure vessels, process equipment, and heavy equipment material failures.

SENIOR METALLURGICAL ENGINEER, ANAMET, A DIVISION OF ACUREN INSPECTION, INC., HAYWARD, CA, 2022

Conducted failure analysis investigations and provided metallurgical consulting services. Validated and reported routine metallurgical, chemical composition, and mechanical testing results. Managed projects and reviewed failure analysis reports produced by Materials Engineers.

### Contact

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## *Professional Highlights, Continued*

SENIOR METALLURGICAL ENGINEER, RTI LABORATORIES, INC., LIVONIA, MI, 2016-2021
Conducted failure analysis investigations and provided metallurgical consulting services. Oversaw metallurgy department and managed technical personnel in the Materials Sciences division of a commercial laboratory. Managed $1M/year Military Sealift Command contract for Testing Laboratory Services. Validated and reported routine metallurgical, chemical composition, and mechanical testing results. Developed standard operating procedures for ISO/IECI 7025:2005 laboratory accreditation, based on ASTM, ASME, AWS and MIL specifications.

METALLURGICAL ENGINEER I FAILURE ANALYST, THE BABCOCK AND WILCOX COMPANY, BARBERTON, OH, 2014-2016
Conducted failure analysis investigations and provided metallurgical consulting services to internal/external clients. Proposed and managed applied R&D projects focused on improving boiler material performance, novel manufacturing methods, and updating OEM standards. Provided technical and translational support for an internal manufacturing facility in Mexico. Supported B&W Research Center as secondary SEM operator.

METALLURGICAL ENGINEER I FAILURE ANALYST I ASSISTANT MANAGER, COLORADO METALLURGICAL SERVICES, AURORA, CO, 2011-2014
Oversaw metallurgy department and managed technical personnel in a commercial laboratory. Derived measurement of uncertainty values associated with testing procedures for incorporation into quality control SOPs and maintaining compliance with 1SO/IEC 17025:2005 laboratory accreditation audits. Developed standard operating procedures for 1SO/IEC 17025:2005 laboratory accreditation, based on ASTM, ASME, AWS and MIL specifications.

## *Notable Publications + Presentations*

PUBLICATIONS, TECHNICAL JOURNALS + BOOKS

Contreras, J.C.; Natividad, S. L.; Stafford, S. W.: "Failure Analysis Case Study on a Fractured Tailwheel Fork," Journal of Failure Analysis and Prevention, ASM International, 2011, DOI 10.1007/sl 1668-011-9466-8.

Contreras, J.C. (2012). Evaluation of Residual, Post-Service Creep-Rupture Properties of S-816 Turbine Buckets (Master's Thesis). Retrieved from Dissertations and Theses database. (UMI No. 11022)

## *Professional Standings*

LICENSES
Licensed Professional Metallurgical Engineer, California, No. 2035
Licensed Professional Engineer, Michigan, No. 6201068240
Licensed Professional Metallurgical and Materials Engineer, Washington, No. 22024076

JENSEN HUGHES

## SCOTT L. ROBERTS CFEI, CVFI, PI

LEAD FIRE INVESTIGATOR

### Bio

Mr. Roberts is the Lead Fire Origin and Cause Investigator and has over 30 years of experience as an investigator, specializing in all aspects of residential, commercial, wildland, and vehicle fire origin and cause determination. He is knowledgeable about standard practices regarding fire scene excavation, evidence collection and chain of custody. He has received extensive training related to gas, electric and incendiary fire investigation and hazardous materials awareness. Mr. Roberts is skilled at identifying potentially hazardous sites and materials, and in taking appropriate actions to conduct thorough examinations.

Mr. Roberts has extensive experience supporting insurance carriers and attorneys in claim subrogation recovery and providing expert testimony for cases originating in Alaska, Montana and Washington jurisdictions.

### Professional Highlights

LEAD FIRE INVESTIGATOR, JENSEN HUGHES, INC., MOUNTLAKE TERRACE, WA, 2001–PRESENT

Lead Fire Investigator conducting various types of investigations, specializing in fire origin and cause investigations. Skilled in identifying potentially hazardous sites and materials, and in taking appropriate actions to conduct thorough examinations. Responsible for fire scene excavation, scene documentation, evidence retrieval, conducting field and formal interviews, performing product liability research and report preparation.

SENIOR INVESTIGATOR, MICHAEL J. GALE & ASSOCIATES, MONROE, WA, 1995–2001

Senior Investigator responsible for various types of insurance investigations, including cause and origin of fires. Conducted forensic reconstruction and testing relating to products of combustion and spontaneous ignition. Performed scope of property damage loss assessment and fire loss claims for insurers, adjusters and law firms. Certified as a Hazardous Material Technician was involved with scene examinations and consultations relating to hazardous materials.

### Education

State of Alaska, Department of Public Safety, Municipal Police Academy, 1980

### Associations

International Association of Arson Investigators (IAAI)

IAAI Hawaii State Chapter (IAAI-HI)

Fraternal Order of Alaska State Troopers (FOAST)

National Association of Fire Investigators (NAFI)

### Awards

Five Police Commendations - Unit Citation

City Council Commendation

Safe Driving Award, Five Year

Two Police Commendation Medals

Two Lifesaving Medals

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## *Professional Highlights, Continued*

INSURANCE INVESTIGATOR, INS INVESTIGATIONS BUREAU, INC., SEATTLE, WA, 1990–1995
Insurance Investigator for nationally recognized firm. Performed all facets of insurance investigation including but not limited to surveillance in bodily injury claims. Responsibilities included leading a team of investigators in major property loss claims. As a Certified Hazardous Materials Technician was responsible for recognizing and identifying potentially hazardous sites and taking appropriate actions to conduct thorough examinations. Highly successful assisting insurance companies with subrogation recovery in numerous fire loss claims. Developed excellent working relationships with insurance carriers, law firms, and public fire and police agencies. Specialized in scene documentation, evidence retrieval, field and formal interviews, product liability research and report preparation. Testified in Washington and Montana courts.

CITY OF KETCHIKAN POLICE DEPARTMENT, KETCHIKAN, AK, 1981–1989

*Patrol Corporal, 1988–1989*

*Police Officer, 1981–1988*
Conducted fire origin and cause, major crimes, homicide and property crimes investigations. In addition to routine patrol in a progressive police department, was also an integral member of the Special Weapons and Tactics Team, and served as the Arson Team Task Force Coordinator. Assisted the Shift Sergeant with supervision of patrol officers.

CITY OF CRAIG POLICE DEPARTMENT, CRAIG, AK, 1980–1981

*Police Chief, 1980–1981*

*Police Officer, 1980*
As the Acting Police Chief, administrated a small police department on Prince of Wales Island in Southeast Alaska. As a Police Officer, was responsible for routine patrol and enforcing local, state and federal laws.

VOLUNTEER SERVICE

*Ketchikan Volunteer Fire Department, Ketchikan, AK, 1981–1989*

*Craig Volunteer Fire Department, Craig, AK, 1980–1981*

*Mason County Sheriff Department Reserve Program, Mason County, WA, 1979–1980*

*Shelton Volunteer Fire Department House Crew, Shelton, WA, 1979–1980*

## *Notable Publications + Presentations*

Roberts, S., "Awareness of Electrical Fire Causes; Fire's Follow Up," East Jefferson Fire Rescue, Port Townsend, WA, February 2012

Roberts, S., "Fire Origin and Cause Investigations," SAFECO Insurance, SIU Meeting, Seattle, WA, October 2007

Roberts, S., "Fire Origin and Cause Investigations," The Life of a Property Loss Seminar, SAFECO Insurance, Redmond, WA, 2004

## *Professional Standings*

### LICENSES

+ Licensed Private Investigator, Alaska, No. PD1094
+ Licensed Private Investigator, Montana, No. 8479
+ Licensed Private Investigator, Nevada, No. R-058944
+ Licensed Private Investigator, Oregon, No. PSID 57173
+ Licensed Private Investigator, Washington, No. 746
+ Certified Fire Investigator, IAAI, No. 17063
+ Certified Fire and Explosion Investigator, NAFI, No. 7238-3318
+ Certified Vehicle Fire Investigator, NAFI, No. 7238-3318V
+ Certified Hazardous Materials Technician, Georgia Technical Institute, 1991, 1993, 1994, 1995
+ Certified Intermediate Police Officer, Alaska Police Standards Council, 1988
+ Certified Special Officer Commission, State of Alaska Department of Public Safety, 1983
+ Certified Special Alaska State Trooper, 1983
+ Certified Basic Police Officer, Alaska State Police Standards Council, 1982
+ Certified AK State and WA State Emergency Medical Technician/Ambulance, NHTSA, 1978
+ Certified Commercial Service, Repair & Refill Portable Fire Extinguishers, Permanent, AK, 1978

### CONTINUED EDUCATION + TRAINING

+ Practical Fire Dynamics, IAAI, 2019
+ 2017 International Training Conference, IAAI, Las Vegas, NV
+ Ethical Duties Beyond the Fire Scene, CFI Trainer.Net, 2016
+ Ethics and the Fire Investigator, CFI Trainer.Net, 2016
+ Wildland Fire Litigation Conference, Monterey, CA, 2016
+ Asbestos Awareness Training, Safety Unlimited, 2016
+ Wildland Fire Litigation Conference, Monterey, CA, 2015
+ Advanced Marine Fire Investigation, Middlesex County Fire Academy, Sayreville, NJ, 2014
+ Investigating Solid Fuel-Burning Appliance Fires, Fire Findings Laboratories, 2013
+ Fire and Materials Conference, San Francisco, February 2013
+ Asbestos Awareness Training, RGA Environmental, 2012
+ 2nd International Conference on Fires in Vehicles – FIVE 2012, Chicago, IL, 2012
+ FI-210: Wildland Fire Origin & Cause Determination, San Diego, 2011
+ FI-210: Wildland Fire Origin & Cause Determination, Boulder, CO, 2010
+ Investigation of Gas & Electric Appliance Fire, Fire Findings Laboratories, 2010
+ Wildland Fire Litigation Conference, Reno, NV, 2010
+ Understanding Post-Flashover Fire Behavior, Carmen & Associates Fire Investigation, 2009
+ Fire Investigation Techniques, 57th Annual Training Conference, IAAI, 2006
+ Electrical Fire Cause Seminar, Schaefer Engineering Corporation, 2005

## *Professional Standings, Continued*

### CONTINUED EDUCATION + TRAINING, CONTINUED

+ Advanced Fire Investigation: NFPA 472 Hazmat Awareness, Fire Scene Death Investigation, Investigating Electrical & Natural Gas Fires, NFPA 921 Update, Courtroom Survival, IAAI, 2004NFPA 921 Fire & Explosion Investigation Course, IAAI, 2001Hazardous Materials & Fire Investigation Safety, Michael J. Gale & Associates, 1998
+ Electrical Fires, Schaefer Engineering Corporation, 1997
+ Inspection of Sprinkler Systems & Hood Suppression Systems, NW WA Chapter of ICBO, 1997
+ NFPA 921 Investigations and HTA Fires, IAAI WA Chapter, 1995
+ Vehicle Fire Seminar, IAAI OR Chapter, 1991
+ Fire Cause Determination, Oregon State Fire Chiefs Association, 1988
+ Fire / Arson Detection, National Fire Academy, 1988
+ 38th IAAI Seminar, Fire Investigation Techniques, IAAI, 1987
+ Advanced Fire Investigative Techniques, Alaska State Fire Marshal's Office, 1986
+ Officer Survival, FBI, WA State Criminal Justice Training Commission, 1986
+ Fire / Arson Investigation, National Fire Academy, 1985
+ Fire Cause Determination, Oregon State Fire Chiefs Association, 1984
+ Arson Detection and Investigation, University of Alaska, 1983
+ Fire / Arson Investigation, State of Alaska, Department of Public Safety, 1983
+ Fire Cause Investigation, Ketchikan Fire Department, 1983
+ Criminal Interrogation and Behavioral Analysis Interviews, Reid College, 1983
+ Special Weapons & Tactics for Small Agencies, FBI, WA State Criminal Justice Training Commission, 1983
+ Impaired Driver Awareness, State of Alaska, Department of Public Safety, 1983
+ Uniformed Investigators School, Anchorage Police Department, 1982
+ Collection, Preservation and Identification of Evidence, State of Alaska Police Standards Council, 1982
+ The Dynamics of Abuse, State of Alaska, Department of Public Safety, 1982
+ Basic Field Training for Recruit Police Officer, Ketchikan Police Department, 1981
+ Essentials of Firefighting, State of Alaska, 1980
+ Search and Seizure Procedure, Alaska District Attorney's Office
+ Emergency Response Team International Training, RCMP/AK
+ Basic Fingerprint and Latent Search Techniques, FBI Sponsored
+ Police Civil Liabilities, Use and Abuse of Force, Ketchikan Police Department

## 7.0 TESTIMONY RECORDS

**Jeffrey Marsh**

| *Deposition* | *Mediation* | *Arbitration* | *Trial* | *Court* | *Case Caption* |
|---|---|---|---|---|---|
| 8/21/23 | | | | Superior Court of WA, King County | David D. Lewis and Susan W. Lewis v. Impact Electrical Services, LLC, et al.; Case No. 22-2-16621-5 SEA |

**Jonathan Contreras**

| *Deposition* | *Mediation* | *Arbitration* | *Trial* | *Court* | *Case Caption* |
|---|---|---|---|---|---|
| | 2/21/2024 | | | United States District Court, District of Nevada | Homesite Insurance Company v. Norcold, Inc., et al.; Case No. 2:21-cv-02167-RFB-DJA |
| 10/18/2022 | | | | Court of Common Pleas of Franklin County, Ohio | The Cincinnati Insurance Company v. Bradford White Corporation; Case No. 20-cv-005768 |

**Scott Roberts**

| Deposition | Mediation | Arbitration | Trial | Court | Case Caption |
|---|---|---|---|---|---|
| 1/9/2024 | | | | US District Court, District of Kansas at Kansas City | Progressive Northwestern Insurance Company a/s/o Chris and Tracy Garling v. Hew Horizons RV Corp., et al.; Case No. 2:23-CV-02083 |
| 9/21/2023 | | | | Superior Court of the State of WA, Mason County | Safeco Insurance Company of America v. Asept-Air, Inc.; Case No. 22-2-00252-23 |
| 2/7/2022 | | | | Superior Court of the State of Washington, King County | Jenelle MacDicken, et al. v. Snohomish County Public Utility District #1 / Grange Insurance Assoc. v. Snohomish County PUD #1; Case No. 19-2-13718-5 SEA |
| 10/12/21 | | | | Superior Court of the State of Washington, King County | Lucy Celes v. Lone Pine Apartments, LLC, et al.; Case No. 16-2-27532-0 SEA |
| 8/26/2021 | | | | Superior Court of WA, Snohomish County | Mid-Century Insurance Company a/s/o Allen Hemat, et al. v. AAble Safety Clean, Inc., et al.; Case No. 18-2-10402-31 |

## 8.0 TRIAL EXHIBITS

Jensen Hughes intends to use any figures, photographs, reference material, or appendices reproduced or referenced in this report and any of the documents, photographs, data, or drawings obtained or produced during the investigation. In addition, Jensen Hughes may use any subject or exemplar items involved in the Jensen Hughes investigation as a trial exhibit.

## 9.0 COMPENSATION

Jensen Hughes charges $350 per hour for investigations and $525 per hour for deposition and testimony provided by Jeffrey Marsh.

Jensen Hughes charges $355 per hour for investigations and $535 per hour for deposition and testimony provided by Jonathan Contreras.

Jensen Hughes charges $225 per hour for investigations and $335 per hour for deposition and testimony provided by Scott Roberts.

Other fees and charges are in accordance with Jensen Hughes Standard Terms and Conditions and Fee Schedule.